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13. ABSTRACT (Maximum 200 words)

Autonomous explosive driven pulsed power devices have a potentially large specific energy. However, the condition for the maximum possible energy output almost never coincides with the condition that would enable driving a pulsed power load effectively. Meaning, that the energy output of an explosive driven device is a very strong function of the load that the device is driving. The authors had previously investigated multiple explosive driven devices and characterized them with respect to their performance under ideal conditions. Based on this knowledge, the investigators (a) explored the performance limits under realistic loads, which included the redesign of existing devices and (b) evaluated the optimum coupling schemes of individual devices aimed towards a considerable energy multiplication from stage to stage. It was demonstrated and clarified what is required to push a few kJ of electrical energy into an inductive storage system utilizing a small (few inches in diameter) multistage explosive driven pulsed power system based on a helical flux compression generator.

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Final Performance Report

on the project

Multistage Explosive Driven Pulsed Power

AFOSR F49620-03-1-0413

For the period August 31, 2003 to July 31, 2004

To:

AFOSR/NE Bob Barker
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September 10, 2004

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Executive Summary

The main focus of the research conducted at the Center for Pulsed Power and Power Electronics in the Electrical Engineering department at TTU has been on understanding and characterization of the operation of helical multistage (dual stage) magnetic flux compression generators (HMFCG) into high impedance loads. This included the addition of a final power conditioning stage between generator and load.

To meet the above goals, the following research efforts were completed during the course of this project:

Design and test of a helical MFCG for large inductive load

Utilizing design guidelines available in the open literature as well as own experience from previous research on single-stage FCGs, a multistage MFCG was developed and successfully tested to deliver a few kJ into a 3 μH load.

The detailed results are published in:
Andreas A. Neuber, Juan-Carlos Hernández, James C. Dickens, Magne Kristiansen, "Helical MFCG For Driving A High Inductance Load," Electromagnetic Phenomena, vol. 3, pp. 397-404, (2003).

Characterization of Intrinsic Losses in Helical MFCGs

It is well known that helical MFCGs suffer from intrinsic loss (other than ohmic losses in the conductors). Prior to this research, the explanation for this intrinsic was more qualitative. Utilizing our experimental findings we developed a model for the intrinsic flux loss that was verified against experimental data.

The detailed results are published in:
Juan-Carlos Hernandez, Andreas A. Neuber, James C. Dickens, and Magne Kristiansen, "Quantification of Ohmic and Intrinsic Flux Losses in Helical Flux Compression Generators," accepted for publication in the Special Issue on Pulsed Power in the IEEE Transactions of Plasma Science, (Oct. 2003)

Design and test of a helical MFCG driven system (300 kV, 10 Ohm load)

An inductive energy storage system was added to the multistage MFCG enabling us to generate several 100 kV into a 10… 15 Ohm resistive load (2" helix

diameter). Such a load impedance is expected from some high power microwave generator, e.g. the virtual cathode oscillator.

The detailed results are published in:
J.-C. Hernandez, A. A. Neuber, M. Giesselmann, J. C. Dickens, and Magne Kristiansen, "Compact FCG Driven Inductive Energy Storage System," MegaGauss X, Berlin, Germany, July 18 -23, 2004, to be published in conference proceedings.

Publications:

1. Andreas A. Neuber, Juan-Carlos Hernández, James C. Dickens, Magne Kristiansen, "Helical MFCG For Driving A High Inductance Load," Electromagnetic Phenomena, vol. 3, pp. 397-404, (2003).
2. J.-C. Hernandez, A. Neuber, J. Dickens, and M. Kristiansen, "Quantification of Ohmic and Intrinsic Flux Losses in Helical Flux Compression Generators," IEEE Transactions, Special Issue on Pulsed Power, 2004.
3. A. Neuber and J. Dickens, "Magnetic Flux Compression Generators," Proceedings of the IEEE, vol. 92, pp. 1205-1215, 2004. (Invited Paper)
4. J.-C. Hernandez, A. A. Neuber, M. Giesselmann, J. C. Dickens, and Magne Kristiansen, "Compact FCG Driven Inductive Energy Storage System," *MegaGauss* X, Berlin, Germany, July 18 -23, 2004, to be published in MegaGauss proceedings.
5. M. Kristiansen, A. Neuber, J. Dickens, M. Giesselmann, and S. Shkuratov, "Compact Pulsed Power," Presented at *MegaGauss X*, Berlin, Germany, July 18 -23, 2004. (Invited)

The Principal Investigator is currently editing a handbook on Magnetic Flux Compression, in which the findings (operating principle, basic physics, design guidelines, etc.) of this research grant and the previous 1998 MURI program (Explosive Driven Pulsed Power) will be summarized. The book will appear in Springer Verlag (contract is being signed) in early 2005.

Students:

One Ph.D. student, Juan-Carlos Llambes Hernandez, has received his doctorate in June 2004 based on the research he did on this contract.
His thesis is entitled:
"Magnetic Flux Compression for High Voltage Pulse Applications", 2004, Ph.D. Thesis, Texas Tech University, 77 leaves, ill., 28 cm.

The core findings of Dr. Hernandez' thesis' are published in the above listed journal and conference publications.

Personnel:

Dr. Andreas A. Neuber, P.E., principal investigator
Mr. Juan-Carlos Llambes Hernandez, (Ph.D. EE, June 2004)
Mr. Daniel Garcia (Technician)

Interactions/Transition:

Dr. Andreas A. Neuber and Dr. Juan Carlos Hernandez traveled to Berlin, Germany, and attended the Megagauss X conference, July 18-23, 2004. Two oral presentations (one invited) primarily based on this research grant were made; see numbers 4 and 5 of publication list.